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## Sources of Wage Inequality<sup>†</sup>

By ANDERS AKERMAN, ELHANAN HELPMAN, OLEG ITSKHOKI,  
MARC-ANDREAS MUENDLER, AND STEPHEN REDDING\*

Theoretical research in international trade increasingly focuses on firm heterogeneity in differentiated product markets following Melitz (2003). A key implication of this line of research is that firms are unevenly affected by trade liberalization: low productivity firms exit, intermediate-productivity domestic firms contract, and high-productivity exporting firms expand. More recent theoretical research has provided conditions under which firm wages vary with firm revenue, which opens up a new channel for trade to affect wage inequality. Trade liberalization that enhances the dispersion of revenues across firms also increases wage inequality across workers and firms.

One line of research assumes competitive labor markets, so that all workers with the same characteristics are paid the same wage, but wages can differ across firms because of differences in work force composition (e.g., Verhoogen 2008 and Yeaple 2005). Another line of research introduces labor market frictions, so that workers with the same characteristics can be paid different wages by different firms. Potential sources of such labor market

imperfections include search and matching frictions (e.g., Davidson and Matusz 2010 and Helpman, Itskhoki, and Redding 2010) and efficiency or fair wages (e.g., Amiti and Davis 2012 and Egger and Kreickemeier 2009).

This class of theoretical models receives strong empirical support. Helpman et al. (2012) develop an extension of the structural model of firm heterogeneity and trade in Helpman, Itskhoki, and Redding (2010) and estimate it using Brazilian employer-employee and trade transactions data. They show that the extended model provides a good fit to the observed distributions of wages and employment across firms. More broadly, Helpman et al. (2012) highlights a number of stylized facts that support the mechanism of firm-based variation in wages within sectors and occupations.

In this paper, we show that many of the same stylized facts are observed using Swedish employer-employee and trade transactions data. Since Brazil and Sweden are countries with different technologies and institutions, the similarity of the results in these two different settings suggests that the stylized facts are systematic features of the data. Nonetheless, we do find some differences between Brazil and Sweden, which are consistent with the view that Sweden's labor market institutions dampen wage dispersion between firms.

The remainder of the paper is structured as follows. Section I summarizes the data. Section II presents evidence on the sources of wage inequality within and between sectors and occupations. Section III shows that similar results hold controlling for observed worker characteristics. Section IV examines the relationship between firm wages and trade participation. Section V concludes.

### I. Data Description

We use linked employee-employer data from Statistics Sweden from 2001–2007. The data

\*Akerman: Stockholm University, Department of Economics, Stockholm, SE-106 91, Sweden (e-mail: anders.akerman@ne.su.se); Helpman: Harvard University, Department of Economics, 1805 Cambridge Street, Cambridge, MA 02138 and CIFAR (e-mail: ehelplan@harvard.edu); Itskhoki: Princeton University, Department of Economics, Princeton, NJ 08544 and WWS (e-mail: itskhoki@princeton.edu); Muendler: UC San Diego, Department of Economics, 9500 Gilman Dr. MC 0508, La Jolla, CA 92093 (e-mail: muendler@ucsd.edu); Redding: Princeton University, Department of Economics, Princeton, NJ 08544 and WWS (e-mail: reddings@princeton.edu). Helpman, Itskhoki, and Redding thank the National Science Foundation for financial support. Akerman thanks the Jan Wallander and Tom Hedelius' Foundation and the Swedish Research Council for financial support. We are very grateful to Itzik Fadlon for excellent research assistance. The usual disclaimer applies.

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TABLE 1—EMPLOYMENT, LOG WAGES, AND EXPORT PARTICIPATION BY INDUSTRY

Industry	Employee share	Relative mean log wage	Exporter		Exporter non-EFTA/EU	
			Share firms	Share emp.	Share firms	Share emp.
Chemicals	6.5	0.15	91.2	98.9	71.5	96.5
Coke and refined petroleum	0.5	0.20	77.8	98.8	61.1	96.4
Electrical and optical equipment	12.0	0.12	71.4	95.5	54.9	91.6
Food, beverages, and tobacco	7.6	−0.06	41.5	86.8	19.1	69.4
Machinery and equipment	14.2	0.01	72.3	93.9	52.7	88.8
Manufacturing n.e.c.	5.0	−0.19	72.9	95.1	36.4	82.0
Metal products	15.2	−0.06	51.1	83.0	26.0	68.3
Nonmetallic minerals	2.5	−0.03	65.0	93.4	33.2	63.6
Publishing	5.4	0.03	55.3	69.7	21.2	39.0
Pulp and paper	5.9	0.05	92.1	99.6	64.2	95.2
Rubber and plastic	3.4	−0.07	85.6	96.8	54.5	80.2
Textiles and apparel	1.2	−0.13	86.8	94.7	59.5	83.0
Transport equipment	15.7	0.01	76.8	97.9	47.2	92.2
Wood products	4.9	−0.10	57.2	85.5	23.4	57.6
Average across sectors			71.2	92.1	44.6	78.8

*Note:* Columns are share of manufacturing-sector employment; log wage minus average log wage in manufacturing sector; share of firms that export; employment share of exporters.

contain a unique identifier for each worker and employer, as well as information on each worker's annual wage, occupation, education and demographics (age, gender, and labor market experience). We concentrate on the manufacturing sector for which theories of firm heterogeneity and trade are likely to be applicable. Since we are interested in wage inequality within and between firms, we focus on firms with five or more employees. We restrict attention to workers earning at least 175,000 Swedish Krona (SEK) per year to exclude part-time workers. We merge this linked employee-employer data with trade transactions data on firm export participation.

We distinguish five occupational categories (Professional and Managerial, Skilled White Collar, Unskilled White Collar, Skilled Blue Collar and Unskilled Blue Collar) and 112 detailed occupations. We consider 14 two-digit sectors (e.g., Textiles and Apparel, Chemicals) and 274 detailed sectors. Finally, we distinguish 21 counties and 290 municipalities.

Table 1 reports some descriptive statistics on employment shares, mean log wages and export participation across the 14 two-digit sectors. In the fourth and fifth columns, we define an exporter based on sales of at least one Swedish Krona outside Sweden. In the fifth and sixth columns, we define an exporter based on sales of at least one Swedish Krona outside the European

Free Trade Association (EFTA) and European Union (EU). Wage dispersion across sectors is smaller in Sweden than in Brazil. In contrast, exporting is more prevalent in Sweden than in Brazil, even when we consider exporting to non-EFTA/EU countries. On average across sectors, exporters to non-EFTA/EU countries account for 45 percent of firms and 79 percent of employment.

## II. Wage Inequality within and between Sector-Occupations

To explore the sources of wage inequality, we begin by decomposing overall wage inequality into within- and between-group components as follows:

$$\frac{1}{N_t} \sum_i (w_{it} - \bar{w}_t)^2 = \frac{1}{N_t} \sum_{\ell} \sum_{i \in \ell} (w_{it} - \bar{w}_{\ell t})^2 + \frac{1}{N_t} \sum_{\ell} N_{\ell t} (\bar{w}_{\ell t} - \bar{w}_t)^2,$$

where workers are indexed by  $i$  and time by  $t$ ;  $\ell$  denotes groups;  $N_{\ell t}$  and  $N_t$  denote the number of workers in each group and overall;  $w_{it}$ ,  $\bar{w}_{\ell t}$ , and  $\bar{w}_t$  are the log worker wage, the average log wage within each group, and the overall average log wage. We use the log wage for

TABLE 2—CONTRIBUTION OF THE WITHIN COMPONENT TO LOG WAGE INEQUALITY

	Level 2001	Change 2001–2007
Overall wage inequality		
Within occupation	62	71
Within sector	95	74
Within sector-occupation	59	66
Within detailed-sector-detailed occupation	48	51
Within sector-occupation-county	56	65
Within sector-occupation- municipality	52	61

*Notes:* Table reports the results of within- and between-group decompositions. Data include five occupations; 14 sectors; 112 detailed occupations; 274 detailed sectors; 21 counties; and 290 municipalities.

the decomposition, because this ensures that its results are not sensitive to units for wages and allows the inclusion of controls for worker observables.

In Table 2, we report the results of the decomposition. Each row corresponds to a different definition of groups: occupations, sectors, sector-occupations, detailed-sector-detailed-occupations, sector-occupation-counties and sector-occupation-municipalities. The first and second columns report results for the level (2001) and change (2001–2007) of wage inequality, respectively. Across each of the rows of the table, we find a substantial contribution for wage inequality within groups. Around 59 percent of the level of wage inequality is within sector-occupations, and 52 percent is within sector-occupation-municipalities.

### III. Worker Observables and Residual Inequality

We now show that these findings are robust to controlling for observed worker characteristics. To do so, we estimate the following Mincer regression for log wages:

$$(1) \quad w_{it} = z'_{it} \vartheta_t + \nu_{it},$$

where  $z_{it}$  is a vector of observable worker characteristics;  $\vartheta_t$  is a vector of returns to worker observables; and  $\nu_{it}$  is a residual. We estimate this regression separately for each year to allow the returns to worker observables to change freely over time.

TABLE 3—LOG WAGE INEQUALITY AND RESIDUAL INEQUALITY

	Level 2001 (percent)	Change 2001–2007 (percent)
Overall wage inequality		
Residual wage inequality	70	87
—within sector-occupation	83	79

*Notes:* The unreported contribution of worker observables equals 100 percent minus the reported contribution for residual wage inequality. The second row reports the within sector-occupation component of residual wage inequality.

Using the parameter estimates from the regression (1), we first decompose overall wage inequality ( $\text{var}(w_{it})$ ) into the contributions of worker observables ( $\text{var}(z'_{it} \hat{\vartheta}_t)$ ) and the residual ( $\text{var}(\nu_{it})$ ). We next decompose residual inequality ( $\text{var}(\nu_{it})$ ) into within- and between-group components using the decomposition from the previous section.

As reported in Table 3, we find that residual wage inequality accounts for over two-thirds of overall wage inequality, and that the vast majority of residual wage inequality is within sector-occupation. This finding that residual wage inequality is even more concentrated within sector-occupations than overall wage inequality is consistent with the fact that much of the variation in worker observables occurs across sector-occupations. It is also in line with theories of firm heterogeneity and trade that emphasize differences in wages within sectors for workers with similar observed characteristics.

### IV. Trade Participation and Between-Firm Inequality

To examine the extent to which residual wage inequality within sectors and occupations occurs between firms, we augment our Mincer wage regression with firm effects ( $\psi_{jt}$ ):

$$(2) \quad w_{it} = z'_{it} \vartheta_t + \psi_{jt} + \nu_{it},$$

where  $j$  indexes firms. We estimate this regression separately for each sector, occupation, and year, which allows the firm effects to change over time, as implied by models of firm heterogeneity and trade in which firm wages change with firm revenue. The estimated firm wage

TABLE 4—COMPONENTS OF LOG WAGE INEQUALITY WITHIN SECTORS AND OCCUPATIONS

	Unconditional log wage		Worker observables Firm fixed effect, $\hat{\psi}_{jt}$	
	Level 2001	Change 2001–2007	Level 2001	Change 2001–2007
Wage inequality within sectors				
Between-firm wage inequality	21	14	19	15
Within-firm wage inequality	79	86	65	76
Worker observables			16	10
Covar observables-firm effects			1	0

Notes: All entries in percent. Decomposition of the level and growth of wage inequality within sector-occupations (employment-weighted average of the results for each sector-occupation).

components ( $\hat{\psi}_{jt}$ ) capture both wage premia for workers with identical characteristics and unobserved differences in work force composition (including average match effects). We focus on both these sources of wage variation because different models within the heterogeneous firm literature place different degrees of emphasis on each source.

Using the parameter estimates from the regression (2), we decompose wage inequality within each sector, occupation, and year ( $\text{var}(w_{it})$ ) into the contributions of worker observables ( $\text{var}(z'_{it}\hat{\vartheta}_t)$ ), between-firm wage inequality ( $\text{var}(\hat{\psi}_{jt})$ ), the covariance of worker observables and between-firm wage inequality ( $\text{covar}(z'_{it}\hat{\vartheta}_t, \hat{\psi}_{jt})$ ), and the residual within-firm wage inequality ( $\text{var}(\hat{\nu}_{it})$ ).

In Table 4, we report this decomposition as well as an analogous decomposition of unconditional wages into within- and between-firm components. We find that the between-firm component accounts for around 20 percent of the level of wage inequality within sectors and occupations, both unconditionally and after controlling for worker observables.<sup>1</sup> This contribution is substantially smaller than in Brazil (around 40 percent), which could reflect the influence of Swedish labor market institutions in dampening wage variation between firms. Worker observables account for around 16 percent of the variation in wages within sector occupations; the covariance between worker observables and the firm wage component contributes around 1

percent, with the remainder attributable to the residual within-firm wage inequality.

The between-firm wage component provides a new channel through which trade can affect wage inequality. As shown in Helpman, Itskhoki, and Redding (2010), the opening of the closed economy to trade necessarily raises within-industry wage inequality within a class of heterogeneous firm models in which (a) firm wages and employment are power functions of productivity, (b) only some firms export, and exporting raises the wage paid by a firm with a given productivity, (c) productivity is Pareto distributed. In this class of models, the wage and employment of firms can be expressed in terms of their productivity ( $\varphi$ ), a term capturing whether or not a firm exports ( $\Upsilon(\varphi)$ ), the zero-profit cutoff productivity ( $\varphi_d$ ), and parameters:

$$l(\varphi) = \Upsilon(\varphi)^{\mu_l} l_d \left( \frac{\varphi}{\varphi_d} \right)^{\zeta_l}$$

$$w(\varphi) = \Upsilon(\varphi)^{\mu_w} w_d \left( \frac{\varphi}{\varphi_d} \right)^{\zeta_w},$$

where  $l_d$  and  $w_d$  are employment and wage of a firm with productivity  $\varphi_d$ ;  $\Upsilon(\varphi) = \Upsilon_x > 1$  for  $\varphi \geq \varphi_x$ ;  $\Upsilon(\varphi) = 1$  for  $\varphi < \varphi_x$ ;  $\varphi_x$  is the exporting productivity threshold; and  $\Upsilon_x$  is the exporter revenue premium given firm productivity.

In Figure 1, we display the empirical distributions of log employment and the log wage component ( $\hat{\psi}_{jt}$ ) for exporters to any destination, exporters to outside EFTA/EU, and nonexporters. Consistent with the class of models above, exporters are, on average, larger and pay higher wages than nonexporters, and these differences become even more pronounced once we focus on exporters outside EFTA/EU. In contrast to the predictions of the class of models above,

<sup>1</sup>This finding is broadly in line with the plant-level results not controlling for occupation in Nordström Skans, Edin, and Holmlund (2009).

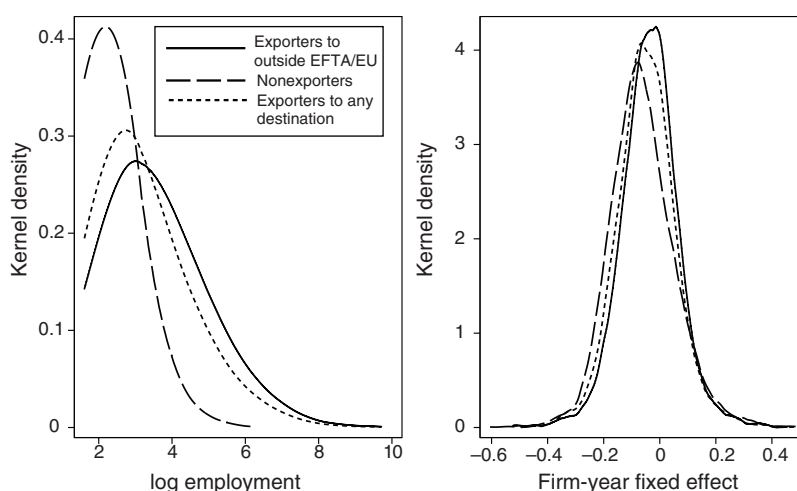


FIGURE 1. DISTRIBUTIONS OF EMPLOYMENT AND LOG WAGES FOR EXPORTERS AND NONEXPORTERS

Note: Kernel density estimates of the distribution of log firm employment and the estimated firm log wage component  $\hat{\psi}_j$  across firms.

there is substantial overlap in the employment and wage distributions of exporters and nonexporters. Additionally, the increase in probability densities at low values for both the firm-year fixed effects and employment is more consistent with a log normal distribution than a Pareto distribution.

Helpman et al. (2012) develop an extension of the above class of models that accounts for these features of the data. Heterogeneity in fixed exporting costs across firms generates overlap in the wage and employment distributions of exporters and nonexporters. Heterogeneity in the costs of screening worker abilities across firms generates an imperfect correlation between wages and employment even conditional on export status. Estimating the extended model, they find that it has substantial explanatory power for the distribution of wages across firms and workers. Counterfactual changes in trade openness result in quantitatively relevant changes in wage inequality across workers through the mechanism of differences in wages between firms.

## V. Conclusions

Analysis of Swedish manufacturing data confirms the main stylized facts about wage inequality found in Helpman et al. (2012) using

Brazilian manufacturing data. A substantial component of wage inequality is within sectors and occupations across workers with similar observed characteristics. One notable difference is a smaller contribution from between-firm differences in wages in Sweden, which could reflect the influence of Swedish labor market institutions in dampening variation in wages between firms through collective wage agreements.

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